

Amendments to the Specification

Please replace paragraph [0007] with the following:

It should be appreciated [[a]] by one of skill in the art that each reaction zone of the plurality of reaction zones may contain one or more catalysts. In one such illustrative embodiment, the catalysts are selected from autothermal reforming catalyst, desulfurization catalyst, water gas shift catalyst, preferential oxidation catalyst as well as mixtures and combinations of these and similar catalysts. Any particular reaction zone containing more than one catalyst may be separated from an adjacent reaction zone by a permeable plate that also serves to support the adjacent reaction zones. In one illustrative embodiment, the plate is selected from perforated metal, metal screen, metal mesh, sintered metal, porous ceramic, or combinations of these materials and similar materials. It is preferred within such an illustrative embodiment that the plate be at least partially composed of ~~inconel~~ INCONEL® (a trademark registered for use in association with nickel alloys and alloys of nickel, chromium and iron), carbon steel, and stainless steel.

Please replace paragraph [0031] with the following:

Process step E' [[F]] is a cooling step performed in one embodiment by a heat exchanger. The heat exchanger can be of any suitable construction including shell and tube, plate, spiral, etc. Alternatively a heat pipe or other form of heat sink may be utilized. The goal of the heat exchanger is to reduce the temperature of the gas stream to produce an effluent having a temperature preferably in the range of from about 90° C. to about 150° C.

Please replace paragraph [0032] with the following:

Oxygen is added to the process in step E' [[F]]. The oxygen is consumed by the reactions of process step G described below. The oxygen can be in the

form of air, enriched air, or substantially pure oxygen. The heat exchanger may by design provide mixing of the air with the hydrogen rich gas. Alternatively, the embodiment of process step D may be used to perform the mixing.

Please replace paragraph [0036] with the following:

The effluent exiting the fuel processor is a hydrogen rich gas P containing carbon dioxide and other constituents which may be present such as water, inert components (e.g., nitrogen, argon), residual hydrocarbon, etc. Product gas may be used as the feed for a fuel cell or for other applications where a hydrogen rich feed stream is desired. Optionally, product gas may be sent on to further processing, for example, to remove the carbon dioxide, water or other components.

Please replace paragraph [0038] with the following:

One of skill in the art after reviewing the above description of FIG. 2 should understand and appreciate that each module performs a separate operational function. Feed stream F (200) is introduced through inlet pipe (not shown) and product gas P 216 is drawn off via outlet pipe (not shown). Reaction zone 208 is the autothermal reforming reaction zone corresponding to process step A of FIG. 1. An electric heater (not shown) may be installed at the bottom inlet of the reactor for start-up heat. Reaction zone 210 is a purifying reaction zone corresponding to process step C of FIG. 1. Reaction zone 212 is a water gas shift reaction zone corresponding to process step E of FIG. 1. The cooling step corresponding to process step E' [[F]] of FIG. 1 is carried out by a heat exchanger 202. Reaction zone 214 is an oxidation step corresponding to process step G of FIG. 1. Air source (not shown) provides a source for oxygen to process gas for the oxidation reaction (Equation V) of reaction zone 214. Reaction zone 214 also contains a heat exchanger 202 positioned within or surrounding the catalyst bed so as to maintain a desired oxidation reaction temperature. One of

skill in the art should appreciate that the process configuration described in this embodiment may vary depending on numerous factors, including but not limited to feedstock quality and required product quality.

Please replace paragraph [0041] with the following:

The preheated fuel leaves the heat exchanger and is routed to the first reaction zone 312 by a reactor feed tube 308. The reactor feed tube may include flow control devices, and the like to condition and optimize the fuel mixture prior to introduction into the first reaction zone 312. The first reaction zone 312 in the present illustrative embodiment is packed with a autothermal reforming reaction catalyst. Such catalyst may be in pellet form or supported on a monolith. In some instances a distribution plate 310 may be needed to achieve an even distribution of fuel to the entire first reaction zone. Also optionally an electric pre-heater (not shown) may be utilized in the start-up of the fuel processor. After the fuel has reacted in the first reaction zone to form a hydrogen rich gas, the natural flow of the gas due to pressure is to flow past the first support plate 314 and thus flow into the second reaction zone 316. In the present illustrative embodiment, the second reaction zone is packed with a desulfurization catalyst, preferably zinc oxide. Passage of the hydrogen rich gas over a desulfurization catalyst, such as zinc oxide, substantially reduces the concentration of sulfur containing compounds in the hydrogen rich gas stream. The temperature of the second reaction zone is at least partially controlled by the third heat exchanger 306 [[304]]. The desulfurized hydrogen rich gas is then passed through the second support plate 318 into the third reaction zone 320. The third reaction zone of the present illustrative embodiment is packed with a water-gas shift reactor catalyst or mixture of such catalyst as discussed above. The passage of the hydrogen rich gas over this catalyst further enriches the hydrogen content and reduces the carbon monoxide concentration. The temperature of the third reaction zone is at least partially controlled by the second heat exchanger 304. The hydrogen rich

gas is then passed through the third support plate 322 and into the fourth reaction zone 324 which contains a preferential oxidation catalyst. Such a catalyst will reduce the carbon monoxide concentration to preferably less than 50 part per million as discussed above. In some instances air or another suitable oxygen source may be injected into the fourth reaction zone so that the preferential oxidation reaction is optimized. This may be accomplished by well known means such as a simple gas injection tube (not shown) inserted into the partial oxidation catalyst bed. In one preferred embodiment porous tube is substantially incorporated into the design of the preferential oxidation reaction zone design and is designed such that an even distribution of injected oxygen is achieved. The temperature of this fourth reaction zone is at least partially controlled by the first heat exchanger 302 which simultaneously preheats the incoming fuel and cools the final product gas exiting the reactor. The final product is a hydrogen rich gas 326. It should also be noted that each of the reaction zones in the illustrative embodiment is separated from any adjacent reaction zone by an inert but porous support plate. Such a support plate is preferably a rigid relatively unreactive under the conditions in the reactor material used in the reaction zone transition regions. Such a material serves to aid in the packing of the reactor with the various catalysts, assists in preventing inadvertent mixing of catalysts during transport and provides a cushioning or buffer zone between each of the differing reaction zones. The hydrogen rich gas is preferably used in a fuel cell or may be stored or used in other processes that should be apparent to one of skill in the art.

Please replace paragraph [0042] with the following:

One of skill in the art after reviewing the above description of FIG. 3 should understand and appreciate that each module performs a separate operational function. Feed stream F (300) is introduced through inlet pipe (not shown) and product gas P 326 is drawn off via outlet pipe (not shown). Reaction

zone 312 is the autothermal reforming reaction zone corresponding to process step A of FIG. 1. An electric heater (not shown) is optionally installed at the bottom of the reactor for start-up heat. Reaction zone 316 is a purifying reaction zone corresponding to process step C of FIG. 1. Reaction zone 320 is a water gas shift reaction zone corresponding to process step E of FIG. 1. The cooling step corresponding to process step E' [[F]] of FIG. 1 is carried out by a heat exchanger 304. Reaction zone 324 is an oxidation step corresponding to process step G of FIG. 1. Air source (not shown) provides a source for oxygen to process gas for the oxidation reaction (Equation V) of reaction zone 324. Reaction zone 324 also contains a heat exchanger 320 positioned within or surrounding the catalyst bed so as to maintain a desired oxidation reaction temperature. One of skill in the art should appreciate that the process configuration described in this embodiment may vary depending on numerous factors, including but not limited to feedstock quality and required product quality.

Please replace paragraph [0045] with the following:

It should be appreciated by one of skill in the art that each reaction zone of the plurality of reaction zones may contain one or more catalysts. In one such illustrative embodiment, the catalysts are selected from autothermal reforming catalyst, desulfurization catalyst, water gas shift catalyst, preferential oxidation catalyst as well as mixtures and combinations of these and similar catalysts. Any particular reaction zone containing more than one catalyst may be separated from an adjacent reaction zone by a permeable plate that also serves to support the adjacent reaction zones. In one illustrative embodiment, the plate is selected from perforated metal, metal screen, metal mesh, sintered metal, porous ceramic, or combinations of these materials and similar materials. It is preferred within such an illustrative embodiment that the plate be at least partially composed of ~~incone~~ INCONEL® (a trademark registered for use in association

U.S.S.N. 10/023,313
Amendment
July 21, 2005

with nickel alloys and alloys of nickel, chromium and iron), carbon steel, and stainless steel.